Major Lightweighting Trends Shaping the Automotive Industry

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Presented by/Date
Brandon Fitzgerald and Sanjay Mazumdar, Lucintel
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• Executive Summary
• Future Lightweight Technologies
• Business Case for Composites
• Market Disruptions
• Conclusions
Executive Summary

• The outlook for light weight materials and composites look strong in the automotive industry

  ➢ Global lightweight materials demand is expected to reach 131 billion lbs in 2025 with a CAGR of ~5%
  ➢ Global sales for automotive parts made with composites such as hood, roof, fender, etc. is likely to reach $28 Bn in 2025 with CAGR of ~5%

• In the automotive industry, purchasing decisions continue to be influenced heavily by the price of the component

• Carbon fiber composites offer a good business case for OEMs and Tier 1 for light weight solutions – depicted by BMW and Plasan case studies

• Major market disruptions are expected in cost reduction, productivity and mass customization to drive competitiveness of composites
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Carbon Fiber Parts are Gaining Momentum but Mostly in High End Cars

Some of the OEMs using carbon fiber composites are: BMW, Audi, General Motors, Ford, Toyota, Ferrari, Lamborghini, Volkswagen

Carbon fiber composites are mostly used in high end cars, such as Lexus LFA, Mustang, R8 Spyder, Aventador LP700-4, etc.
### Key Lightweight Technologies Used to Manufacture Automotive Parts

<table>
<thead>
<tr>
<th>HSS/AHSS</th>
<th>Aluminum</th>
<th>Glass Composites</th>
</tr>
</thead>
<tbody>
<tr>
<td>· Stamping</td>
<td>· Stamping</td>
<td>· Compression Molding</td>
</tr>
<tr>
<td>· Usibor (A-pillar, Bumper Beam, B-Pillar, C-Pillar, Door Beam)</td>
<td>· Stamping, Casting, Extrusion</td>
<td>· Injection Molding</td>
</tr>
<tr>
<td>· Fuel Tank Guard</td>
<td></td>
<td>· RTM</td>
</tr>
<tr>
<td>· Body in White</td>
<td></td>
<td></td>
</tr>
<tr>
<td>· Door Panels</td>
<td></td>
<td></td>
</tr>
<tr>
<td>· Axle Carrier</td>
<td></td>
<td></td>
</tr>
<tr>
<td>· Engine Cradle</td>
<td></td>
<td></td>
</tr>
<tr>
<td>· Dash Panel</td>
<td></td>
<td></td>
</tr>
<tr>
<td>· Crash Box</td>
<td></td>
<td></td>
</tr>
<tr>
<td>· Side Rail</td>
<td></td>
<td></td>
</tr>
<tr>
<td>· Seat Frame</td>
<td></td>
<td></td>
</tr>
<tr>
<td>· Heat Shield, Bumpers, Hoods, and Closure Panels: (Stamping Process)</td>
<td></td>
<td>· Intake Manifold: (Injection Molding)</td>
</tr>
<tr>
<td>· Powertrain (Engine Block, Transmission): (Casting Process)</td>
<td></td>
<td>· Hood: (Compression Molding)</td>
</tr>
<tr>
<td>· Chassis &amp; Suspension, Heat Exchangers: (Extrusion Process)</td>
<td></td>
<td>· Door Module: (Compression Molding)</td>
</tr>
<tr>
<td>· Oil Pan</td>
<td></td>
<td>· Radiator End Tank: (Injection Molding)</td>
</tr>
</tbody>
</table>

**Key Applications (Process)**

- **HSS/AHSS**
  - Usibor (A-pillar, Bumper Beam, B-Pillar, C-Pillar, Door Beam)
  - Fuel Tank Guard
  - Body in White
  - Door Panels
  - Axle Carrier
  - Engine Cradle
  - Dash Panel
  - Crash Box
  - Side Rail
  - Seat Frame

- **Aluminum**
  - Heat Shield, Bumpers, Hoods, and Closure Panels: (Stamping Process)
  - Powertrain (Engine Block, Transmission): (Casting Process)
  - Chassis & Suspension, Heat Exchangers: (Extrusion Process)

- **Glass Composites**
  - Compression Molding
  - Injection Molding
  - RTM
**Key Lightweight Technologies Used to Manufacture Automotive Parts**

<table>
<thead>
<tr>
<th>Carbon Composites</th>
<th>Natural Composites</th>
<th>Magnesium</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Prepreg Layup</td>
<td>• Compression Molding</td>
<td>• Casting</td>
</tr>
<tr>
<td>• Resin Infusion (HP-RTM)</td>
<td></td>
<td>• Extrusion</td>
</tr>
<tr>
<td>• Monocoque: <em>(Prepreg &amp; RTM Process)</em></td>
<td>• Door Panel</td>
<td>• Door Inner, Roof Frame, Lift Gate Inner, Pillar: <em>(Casting Process)</em></td>
</tr>
<tr>
<td>• Hood: <em>(Prepreg Layup)</em></td>
<td>• Seat Back</td>
<td>• Support Beam, Connectors, Side Rails: <em>(Extrusion Process)</em></td>
</tr>
<tr>
<td>• Door Panel: <em>(Prepreg Layup)</em></td>
<td>• Load Floor</td>
<td></td>
</tr>
<tr>
<td>• Roof: <em>(Prepreg Layup)</em></td>
<td>• Interior Panels</td>
<td></td>
</tr>
<tr>
<td>• Body Panels: <em>(Prepreg Layup &amp; RTM Process)</em></td>
<td>• Under Body Shields</td>
<td></td>
</tr>
</tbody>
</table>

*Cont’d*
Future Automotive Materials Will See Increased Usage of Lightweight Materials


<table>
<thead>
<tr>
<th>Year</th>
<th>Lightweight Materials</th>
<th>Conventional Materials</th>
</tr>
</thead>
<tbody>
<tr>
<td>2010</td>
<td>310 B lbs</td>
<td>82%</td>
</tr>
<tr>
<td>2017</td>
<td>374 B lbs</td>
<td>76%</td>
</tr>
<tr>
<td>2025</td>
<td>431 B lbs</td>
<td>70%</td>
</tr>
</tbody>
</table>

CAGR (2017-2025)

- HSS (>550 Mpa): ~6.9%
- Aluminum: ~4.3%
- Plastics: ~2.6%
- CFRP: ~9%
- Other Composites: ~3.6%
- Magnesium: ~8%

Source: Lucintel
Emission Reduction Targets in the Global Automotive Industry

97 g/km of CO₂ = 54.5 mpg

Source: ICCT
In Highway Driving, 10% Weight Saving Gives about 7% Fuel Saving

Sample Size: 34 (Data from recent OEM makes) 

Source: Lucintel
On City Driving, 10% Weight Saving Gives about 11% Fuel Saving

\[ y = -0.0082x + 49.935 \]
\[ R^2 = \sim 0.90 \]

Source: Lucintel

Sample Size: 34 (Data from recent OEM makes)
### Advanced Materials Offer Considerable Weight Savings at High Costs

#### Structural Application

<table>
<thead>
<tr>
<th>Relative Part Weight</th>
<th>Relative Part Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Steel</td>
<td>100%</td>
</tr>
<tr>
<td>AHSS</td>
<td>120%-140%</td>
</tr>
<tr>
<td>Aluminum</td>
<td>150%-230%</td>
</tr>
<tr>
<td>CFRP</td>
<td>700%-900%</td>
</tr>
</tbody>
</table>

#### Non Structural Application (Fender)

<table>
<thead>
<tr>
<th>Relative Part Weight</th>
<th>Relative Part Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Steel</td>
<td>100%</td>
</tr>
<tr>
<td>AHSS</td>
<td>110%-130%</td>
</tr>
<tr>
<td>Plastics</td>
<td>100%-110%</td>
</tr>
<tr>
<td>Aluminum</td>
<td>120%-140%</td>
</tr>
<tr>
<td>CFRP (RTM)</td>
<td>500%-700%</td>
</tr>
</tbody>
</table>

### Drivers

- **CAFÉ Requirement**
- **CO₂ Emission**

*Source: Lucintel*
## Opportunities for Lightweight Materials in terms of Fuel Saving and CO2 emission Saving Potential

<table>
<thead>
<tr>
<th>Weight Reduction (of Total Vehicle Weight)</th>
<th>Fuel Saving ($) (Life Time Saving Per Vehicle)</th>
<th>CO2 Emission Saving (Gram/km Per Vehicle)</th>
</tr>
</thead>
<tbody>
<tr>
<td>HSS/AHSS</td>
<td>@20% Use of Lightweight Materials</td>
<td>@40% Use of Lightweight Materials</td>
</tr>
<tr>
<td>2.5%</td>
<td>$170</td>
<td>4.4</td>
</tr>
<tr>
<td>4.9%</td>
<td>$340</td>
<td>8.9</td>
</tr>
<tr>
<td>Aluminum</td>
<td>@20% Use of Lightweight Materials</td>
<td>@40% Use of Lightweight Materials</td>
</tr>
<tr>
<td>9.3%</td>
<td>$641</td>
<td>16.8</td>
</tr>
<tr>
<td>18.7%</td>
<td>$1,283</td>
<td>33.6</td>
</tr>
<tr>
<td>Glass Composites</td>
<td>@20% Use of Lightweight Materials</td>
<td>@40% Use of Lightweight Materials</td>
</tr>
<tr>
<td>7.5%</td>
<td>$518</td>
<td>13.6</td>
</tr>
<tr>
<td>15.1%</td>
<td>$1,036</td>
<td>27.2</td>
</tr>
<tr>
<td>Carbon Composites</td>
<td>@20% Use of Lightweight Materials</td>
<td>@40% Use of Lightweight Materials</td>
</tr>
<tr>
<td>21.0%</td>
<td>$1,443</td>
<td>37.8</td>
</tr>
<tr>
<td>42.0%</td>
<td>$2,887</td>
<td>75.6</td>
</tr>
<tr>
<td>Magnesium</td>
<td>@20% Use of Lightweight Materials</td>
<td>@40% Use of Lightweight Materials</td>
</tr>
<tr>
<td>14.0%</td>
<td>$962</td>
<td>25.2</td>
</tr>
<tr>
<td>28.0%</td>
<td>$1,924</td>
<td>50.4</td>
</tr>
</tbody>
</table>

Source: Lucintel
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How to Grow and Develop Competitive Edge for Composites

• About 131 bil lbs light weight materials will be used in 2025 by auto OEMs

• Purchasing decisions continue to be influenced heavily by price of the component

• To develop a competitive edge in the automotive market, the industry needs to focus on the opportunities and innovations below:
  
  ➢ **Price Reduction**: Look for cost reduction in composite parts from various ways such as raw material cost, labor cost, energy cost, etc.
  
  ➢ **Need for Innovative Manufacturing Technologies**: Development of transformative manufacturing technologies with reduced cycle time for manufacturing complex parts.
  
  ➢ **Develop Robust Supply Chain**: Invest in developing global supply chain for raw materials, design, tooling and manufacturing for composites.
  
  ➢ **Develop Better Simulation and Prediction Techniques**: Marketplace needs to come up with better simulation software for manufacturing of composite parts.
  
  ➢ **Need for Investment in Repair and Recycling Technologies**: Solve OEM challenges regarding repair and recycling by developing cost effective technologies
Business Case 1: Why BMW Chose Carbon Composites

Factors Driving the Use of Carbon Composites by BMW

- **A**  Weight Saving
- **B**  Emission Reduction
- **C**  Part Consolidation
- **D**  Strength and Safety gains
- **E**  Efficiency Improvement

Strategies Adopted by BMW to Ensure Effective Usage of CF Materials

- High Cost of carbon fiber restricts its usage in high volume vehicles
- Continuous availability
- High cycle time

Challenges to adopt Carbon Fiber

- BMW & SGL jointly invested to establish carbon fiber manufacturing plant at Moses Lake
- The facility supplies CF and preforms for BMW i vehicles & 7 series
- This strategy helps BMW to have control over CF prices

Solutions
Increasing Usage of Carbon Fiber will Significantly Cut Vehicle Mass

Weight Saving in BMW Cars with Increasing Usage of Carbon Fiber

<table>
<thead>
<tr>
<th>Vehicle Mass (lbs.)</th>
<th>BMW M3</th>
<th>BMW M4</th>
<th>BMW i8</th>
<th>BMW i3</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>3,350</td>
<td>3,300</td>
<td>3,274</td>
<td>2,634</td>
</tr>
</tbody>
</table>

**CF Applications in BMW Car Models**

- Driveshaft-M4
- Roof-BMW M3
- Trunklid-BMW M4
- Life Module-BMW i3 & i8

*Source: Lucintel*

Note: 5% weight reduction in the new BMW M3 and M4 model over its predecessors with the use of CF
High Usage of Carbon Fiber in EVs Offers Significant Weight Saving and Improved Mileage

Mileage Comparison

<table>
<thead>
<tr>
<th></th>
<th>Tesla Model S</th>
<th>Nissan Leaf</th>
<th>BMW i3</th>
</tr>
</thead>
<tbody>
<tr>
<td>MPGe (MPGe)</td>
<td>~19%</td>
<td>~9%</td>
<td>~19%</td>
</tr>
</tbody>
</table>

Price Comparison

<table>
<thead>
<tr>
<th></th>
<th>Tesla Model S</th>
<th>Nissan Leaf</th>
<th>BMW i3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Price ($)</td>
<td>~43%</td>
<td>~19%</td>
<td></td>
</tr>
</tbody>
</table>

Weight Comparison

<table>
<thead>
<tr>
<th></th>
<th>Tesla Model S</th>
<th>Nissan Leaf</th>
<th>BMW i3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Weight (lbs.)</td>
<td>~43%</td>
<td>~19%</td>
<td></td>
</tr>
</tbody>
</table>

High CF content in BMW i3 has improved its mileage

BMW i3 price lies in between the two models & offers high weight saving and mileage which makes it more competitive

Source: Lucintel
In the Last Four Years, Carbon Fiber Composites in the Automotive Industry was Driven by BMW i3 and i8 Model

**Global BMW i3 and i8 Sales: 2014-2017**

- **Key Insights**
  - High cost of carbon fiber impact the profitability of BMW i3 and i8 models, but its make the vehicle lightweight.
  - In last four years, carbon fiber composites in automotive industry was driven by BMW i3 and i8 models.
  - BMW is facing cost pressure from other electric vehicle suppliers, which is likely to impact the carbon fiber demand.
  - BMW is working on ways to reduce the cost of carbon components.

**Source: Lucintel**
Business Case 2: Plasan Revenue Increased 20 Times in Five Years from Carbon Composites

- **Plasan: Revenue Analysis (2011-2020)**

<table>
<thead>
<tr>
<th>Year</th>
<th>$ Million</th>
</tr>
</thead>
<tbody>
<tr>
<td>2011</td>
<td>5</td>
</tr>
<tr>
<td>2015</td>
<td>100</td>
</tr>
<tr>
<td>2020</td>
<td>180</td>
</tr>
</tbody>
</table>

$+8.4%$

- **Company Introduction**
  - **Plasan Carbon Composites** is a carbon fiber component manufacturer, mainly for the automotive industry.
  - Company transformed itself from low volume producer of composites components to high volume carbon composites part supplier in 10 years.
  - The company is on pace to earn revenue of $150 million in 2020 from $5 million in 2011.
  - The company is continuously developing carbon composites parts for OEMs offering weight saving solutions.

Source: Lucintel
Voice of the Market: Need for Light Weight Options with Good Business Case

We are evaluating all material options such as AHSS, Aluminum, Magnesium, Glass Composites and Carbon Composites for making automotive parts. Any material option should have a good business case without sacrificing safety, part count, and other requirements.

Our top management is asking us to reduce weight by almost 50% in various platforms. We are looking into various material options. Significant weight saving potential is available in closure panels such as door panels, deck lids, and hood. We encourage component and material suppliers to come up with better solutions for our vehicle.

Cost is a challenge with bio-composites as most users are not willing to pay a premium. Scale-up is needed for bio-composite materials for better economics.

There is an increasing demand for low density materials in automotive and commercial vehicle market. We are continuously working to develop products with lower density using different combinations of raw materials. We are closely working with Tier 1 players and also OEMs to identify the future of new materials in structural and semi structural automotive applications.
Voice of the Market: Material and Component Suppliers Need to Develop Better Lightweight Solutions

Government in North America has passed mandatory regulations, i.e. CAFÉ standards to improve the fuel economy. In order to improve the fuel economy, we need to work on the weight reduction in our trucks. We are looking into composites and other material options for making of our truck components.

Director, Peterbilt

We have been using composite on our components for a long time and are satisfied with its performance, though we are open to opt a newer materials offering better mechanical and aesthetic properties with light weight. We tend to depend on component suppliers and material manufacturer for new applications for our vehicles.

Engineer, Mercedes Benz Trucks

We use many SMC components such as bumper, roof cap, cabin structure, door extensions and fenders for our Trucks. For our Bus, we use hand lay-up and RTM process to manufacture composites parts. We are looking for new materials and technologies to make various components.

Engineer, MAN SE
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• Conclusions
# Major Disruptions are Expected to Strengthen the Competitiveness of Composites

<table>
<thead>
<tr>
<th>Major Developments</th>
<th>Enablers</th>
<th>Impacted Industries</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cost Reduction in Carbon fiber</td>
<td>Alternative precursors, such as lignin, olefin, textile PAN, etc. Someone will launch low cost carbon fiber ($3 - $6 per lb) in future</td>
<td>• Automotive</td>
</tr>
<tr>
<td>Improvement in Productivity</td>
<td>Low cure resins and faster and dependable technologies. Part manufacturing process with cycle time of 1 to 2 minutes for mass production</td>
<td>• Industrial</td>
</tr>
<tr>
<td>Mass Customization</td>
<td>3D printing for different composites applications especially in automotive and healthcare</td>
<td>• Aerospace</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Aerospace</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Healthcare</td>
</tr>
</tbody>
</table>

## Major Developments

- **Cost Reduction in Carbon fiber**
- **Improvement in Productivity**
- **Mass Customization**
Reduction in Carbon Fiber Costs could double Revenues from the Automotive Industry

<table>
<thead>
<tr>
<th>Car Type</th>
<th>Production in 2025</th>
<th>Expected Demand of CF @ Current Price in 2025</th>
<th>Expected Demand of CF @ $5/lb in 2025</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>CF Usage in % of cars</td>
<td>Demand in M lbs</td>
</tr>
<tr>
<td>Super Cars</td>
<td>8,000</td>
<td>100%</td>
<td>1.6</td>
</tr>
<tr>
<td>Super Luxury Cars</td>
<td>800,000</td>
<td>95%</td>
<td>60.8</td>
</tr>
<tr>
<td>Luxury Cars</td>
<td>5.5 Million</td>
<td>55%</td>
<td>75.6</td>
</tr>
<tr>
<td>Other/Regular Cars</td>
<td>112 Million</td>
<td>3%</td>
<td>5.0</td>
</tr>
</tbody>
</table>

Global Light Vehicles Production in 2025: 118 Million

Source: Lucintel
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Conclusions – How Companies should Prepare

• About 131 bil lbs light weight materials will be used in 2025 by auto OEMs.

• Although current costs for Carbon fiber composites are high, they represent good business opportunities in terms of offering light-weight solutions.

• Demand for carbon composites in the automotive industry is expected to continue to grow based on innovations in materials, technologies and applications in combination with continued cost reductions.

• To develop a competitive edge in automotive composites, the marketplace needs to invest in cost reduction, technology development, simulation, repair, recycling and robust supply chain development.

• Companies in the composites industry need to have clear strategies and objectives for how they want to compete (what materials, applications, segments, technology, etc.)
Conclusions – How Companies should Prepare

• Lucintel can help you define and implement a strategy designed to grow your business, more specifically to:
  
  ➢ **Identify and evaluate attractive opportunities:** Develop dynamic understanding of the relevant market segments you target where you should compete, broken down by segment, application, technology and region. What gaps exist to realize full potential? Also, to develop a short list of specific investment opportunities
  
  ➢ **Finance your Growth:** Help you secure the financing needed to implement your chosen strategy
Appendix: About Lucintel and Case Study for Growth
Lucintel’s Expertise in Unlocking Your Potential

- Founded in 1998. Team of over 100 full time analysts and consultants
- Management consulting firm (M & A, market entry, growth consulting) of choice with deep expertise in materials, technology & market
- Done over 300+ consulting projects in various materials (composites, adhesives, coating, etc.) and hundreds of consulting projects in end segments (Automotive, Construction, Aerospace, etc.). Subject matter expertise
- Great networking - over 20,000 contacts
- Strong testimonials in consulting and market research
  - “I was very happy with Lucintel’s work. It helped us in making a confident investment decision. They delivered the project in a timely manner.” – Dave Finley, Managing Director, Sverica
1000+ Clients in 70 Countries Value Our Service
About Speaker

Sanjay Mazumdar, PhD.

CEO, Author, Thought Leader & Strategist

• Offered advisory services (M & A, market entry, growth consulting, due diligence) to hundreds of clients over 15+ yrs.
• Subject matter expert in the chemical and advanced materials market
• Worked for General Motors in ultra-lightweight project and received 2 Record of Inventions
• Awarded two Society of Plastics Engineers Awards and one DuPont Plunkett Award
• Sought-after speaker at conferences and annual board meetings, helping companies with their growth objectives. Panelist at conferences with industry leaders (Airbus, Boeing, Owens Corning, Core Molding, etc.)
Case Study 1: Growth Opportunity for a Leading Prepreg Manufacturer

Challenge

- A leading prepreg supplier wanted to know about the opportunity for glass and carbon fiber prepreg in Europe and North America across various sectors

Objectives

- To estimate growth opportunities for glass and carbon fiber prepreg across sectors including rail, marine, construction, automotive, defense, infrastructure, and sporting goods in NA and Europe
- Find out prepreg consumption by molders in each sector by application and prepreg type
- Conduct *Voice of Market analysis* and *Go To Customer List* in North America and Europe

Solutions

- Lucintel identified the most attractive target applications in each region for the client based on the client’s core competency
- Lucintel conducted interviews with >700 companies to find out their prepreg consumption patterns and provided Go To Customer List of >250 molders
- Lucintel developed short, medium & long term strategy in the most attractive markets with action plan

Results

- The company’s sales for the relative growth segments grew by 25% over 2 years
Case Study 2: Growth Opportunity for a Leading Pipe Manufacturer in Composite Pipes

Challenge
- A leading FRP pipe manufacturer in the US wanted to know about the opportunity existing for them in composite pipes applications in the US and Canada

Objectives
- To identify total opportunity for FRP pipe and steel pipes
- Identify the addressable market (new/replacement) for FRP pipes for the client based on their core competencies (Diameter, pressure rating, etc.)
- Conduct market share analysis, price vs performance analysis with competing materials, customer identification, and customer requirement analysis in various diameter ranges

Solutions
- Lucintel identified addressable market opportunity based on client core competencies and looked into competing materials performance over the last 10 years
- Lucintel provided Go To Customer List with $50 million dollar sales opportunity in next 10 years
- Lucintel developed short, medium and long term strategy with detail actionable plan

Results
- The company’s sales grew by 35% over 2 years
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